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SHIELDING STRUCTURE FACILITIES FOR ATOMIC ENERGY RESEARCH

by Frank Ring, Jr.

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SHIELDING STRUCTURE FACILITIES FOR ATOMIC ENERGY RESEARCH

Frank Ring, Jr.[1]

An attempt has been made in this paper to discuss the configurations and uses of shielding structures employed in Atomic Energy research and development work. In this sense this paper might be considered as a supplement to Mr. H. M. Glen's paper on "Hot Cell Design".

Primarily, the shielding structure of cells is used as protection against gamma radiation. To "Gadgeteers" it is the barrier which must be crossed by remote controls. The shielding varies from distance in air to 5 and 7 feet of concrete. The more common shields for gamma radiation are lead, steel and poured concrete and concrete block.

In order to set up, reach, and operate our remotely controlled devices we require that the barrier walls and roof structure be penetrated with access tubes with stepped diameters, manipulator holes, spiral pipe and wire holes, large rectangular and circular window framings, stepped access doors, roof plugs and transfer device castings. We further require that the barrier walls be homogeneous with specified density of shielding material maintained all around the penetrations regardless of their configuration or location. As a further requirement we must sometimes have the penetrations very accurately located.

Now what kind of work is done inside these shielded enclosures? A broad answer to this would be most any development, test or experimental work which is required to be carried on in a normal development laboratory and with about the same degree of precision. To list a few categories of in-cell work we have:

Laboratory Scale Chemical Processes
Pilot Plant Chemical Processes
Metallurgical Tests — such as profile, hardness, impact, tensile, and the preparation of test metalographical specimens such as cutting, grinding, polishing and gaging.
Process and Sample Analysis to determine specific gravity, viscosity, acidity and composition.
General machine shop operations consisting of lathe work, drilling, milling, cutting and grinding.

There are two basic philosophies of approach to carrying on this cell work. One is that the work be carried on within the cell using a pair of remotely operated hands or manipulators to operate normal or standard experimental apparatus. The other philosophy is to have each individual piece of apparatus remotely controlled and use conveyors for transport operations. These two basic philosophies have a considerable effect on hot cell design.

In Fig. 1 is shown a very simple concrete shielding wall which is 24" thick concrete seven feet in height and 50 feet long. Liquid radioisotopes are

1. Superintendent of Design, Oak Ridge National Laboratory, Oak Ridge, Tennessee

stored behind the concrete barrier wall. The storage manipulator travels along the wall on two tracks which might be aligned with reasonable accuracy to permit the manipulator to travel along the wall with good stability and free from vibration. The manipulator mechanism provides the "x", "y" and "z" motion as well as the tong clamping action. These are all controlled by the operator with hand wheels driving sprocket wheels, chains, lead screws and spline shafts. At the left side of the picture is shown large hinged covers operated by foot pedals. These covers are normally closed and provide a tunnel enclosure for the ventilation of the bottle storage area. Viewing of the tong head and storage bottles is by the overhead mirrors and the periscope system built into the manipulator.

Fig. 2 shows a lead shielding wall which forms the front of an open top cell. This wall is 5" thick and 7 feet high. The access doors are shown in their open position and the stepped construction to eliminate radiation crack leakage is quite apparent. An electric rectilinear type of manipulator is used in this cell and its longitudinal travel is along the two rails at the rear wall of the cell. The electric control box provides control for the x, y and z motions of manipulator as well as the wrist swing, wrist rotation and grasping action of the tong end. The instrument at the right side of the opening is a periscope with electric power drive for its location and its lenses and mirror system. This periscope is supported on rails which are mounted on the top of this lead barrier wall.

A group of four totally enclosed cells is shown in Fig. 3. The walls of these cells are 3 foot thick and are constructed of high density barytes concrete block. Viewing windows are Zz BR_2 solution filled with 2" thick laminated glass cover plates. The windows are tilted about 1/2" to concentrate the trapped air at one end to facilitate it's removal via the expansion glass shown above each window. These windows measure 24" x 24" x 36" deep and 24" x 48" x 36" deep. The floor areas of the interiors of the cells measure 7' 0" x 3' 6", 3' 2" x 3' 6" and 7' x 5' 3".

The large cells are provided with 2 pantograph type manipulators and the small cells are provided with one each. A 6" thick steel roof slab is provided over the first large cell at the left. This roof slab can be moved longitudinally 12" in either direction to increase the effective volume covered by the 2 manipulators which are mounted on this roof slab.

Personnel access to each of the four cells is by way of built-up block doors which travel on track guided dollies. See Fig. 4. These doors are stepped to prevent radiation leaks. These cells are used by the Solid States Division at the Oak Ridge National Laboratory.

In Fig. 5 is a view through one of the smaller 3 foot thick liquid windows. The slave end of the manipulator is operating the cross feed lever of a small lathe which is mounted in a vertical position.

Fig. 6 shows the exterior of a bank of three 6' x 11" cells. Poured high density concrete was used for the 3 foot thick walls. The liquid filled windows are roughly three foot cubes with 1" thick welded frames. Formed oversized openings were provided in the walls and the frames were installed at a later date by grouting. Many access holes are provided around the windows for insertion of all types of control rods, tubes, and wiring and piping. The wall sections between cells are removable with a crane and they also contain a hydraulically operated sliding door to enable the manipulator to travel from one cell to another. The pistol grip controller for the manipulator is shown at the left lower corner of the first cell window.

It is general practice to keep cell interiors at a slight negative pressure to insure that all air leakage will be inward so that no contaminated air leaves the cells and enters areas where personnel are stationed. These cells are ventilated by drawing the air out of the top of the cells to a filter and stack discharge area. The make up air enters at the floor level of the cells.

The forms and penetrations shown in Fig. 7 illustrate some of the problems of maintaining uniformity of density through out the structure and especially around the penetrations. This picture was taken during the construction of this cell block.

Fig. 8 is a rear view of this cell block. One of the access doors is shown in the open position. The wall transfer device is shown with its carrier mounted on the wall transfer shelf. A more detailed picture of this wall transfer casting and carrier is shown in Fig. 9. Radioactive specimens are loaded into the carrier specimen drawer under 13 foot of water via the top opening of the carrier. When the carrier is positioned on the locating bars of the wall transfer device the specimen drawer is pushed from the carrier, through the mating holes in the wall transfer casting and then into the interior of the cell. The general purpose manipulator is used to remove the specimen from the drawer.

In Fig. 10 the interior of one of the 6' x 11' floor area cells is shown with the heavy duty electrically controlled manipulator. This manipulator is mounted on a crane-like device which runs on rails at the front and rear walls of the cells. The manipulator has the usual x, y and z motions for positioning, wrist swing, wrist rotation and tong gripping action. The tongs are remotely interchangable. Adjustable motorboat spot lights are used for the intense spot lighting. The spot light control tube extends through the 3 foot thick wall. Sodium vapor lights are used for general cell lighting. A stainless steel floor with cove base is shown. The liquid filled window and several plugged access holes are also shown.

One of these cells contains a complete and remotely controlled machine shop set up. Fig. 11 shows a cut-away view of this shop. In order to locate all of the machine tools at one viewing window the lathe was mounted vertically. This vertical mounting facilitates chip removal and of course saves room. The lathe controls are shown at the left side of the window. The milling machine is positioned directly in front of the window with its base located in a pit so that its table is at a good viewing height. The controls for the milling machine table penetrate the wall below the window. A grinder is attached at the top of the milling machine and it can be swung down to table height for grinding. The remote controls for these machines are largely mechanical and hydraulic. Hydraulic motors are used to drive the machine tools with the pump located outside the cell. A high velocity vacuum cleaning system is used to gather the machining chips as they are produced. The chip laden air is piped inside the wall to a cyclone and filter and the chips drop into a chip can located behind a remotely operated lead door shown in the background.

Fig. 12 shows a cut-away view of bank of 4 cells which are used to set up and operate small scale chemical processes. These cells are each 6' x 8' in floor area and 14' high. No traveling manipulator is used in these cells. Large laminated glass windows and periscopes pointed at the corners of the cells are used for viewing. The walls are 3 foot thick concrete. Note the many stepped doors which are used for access for setting up the equipment and the many access tubes for wires, tubes and extended valve handle controls. The top stepped plug is removed for bringing in large pieces of apparatus. Fig. 13 shows the outside walls of the completed cell bank.

A line drawing of an automatic storage, decapping and sampling configuration is shown on Fig. 14. As many as 12 radioactive liquid storage bottles can be sampled at once behind the 2 foot thick concrete barrier wall. The concrete barrier wall is penetrated with hydraulic cylinders, windows and doors.

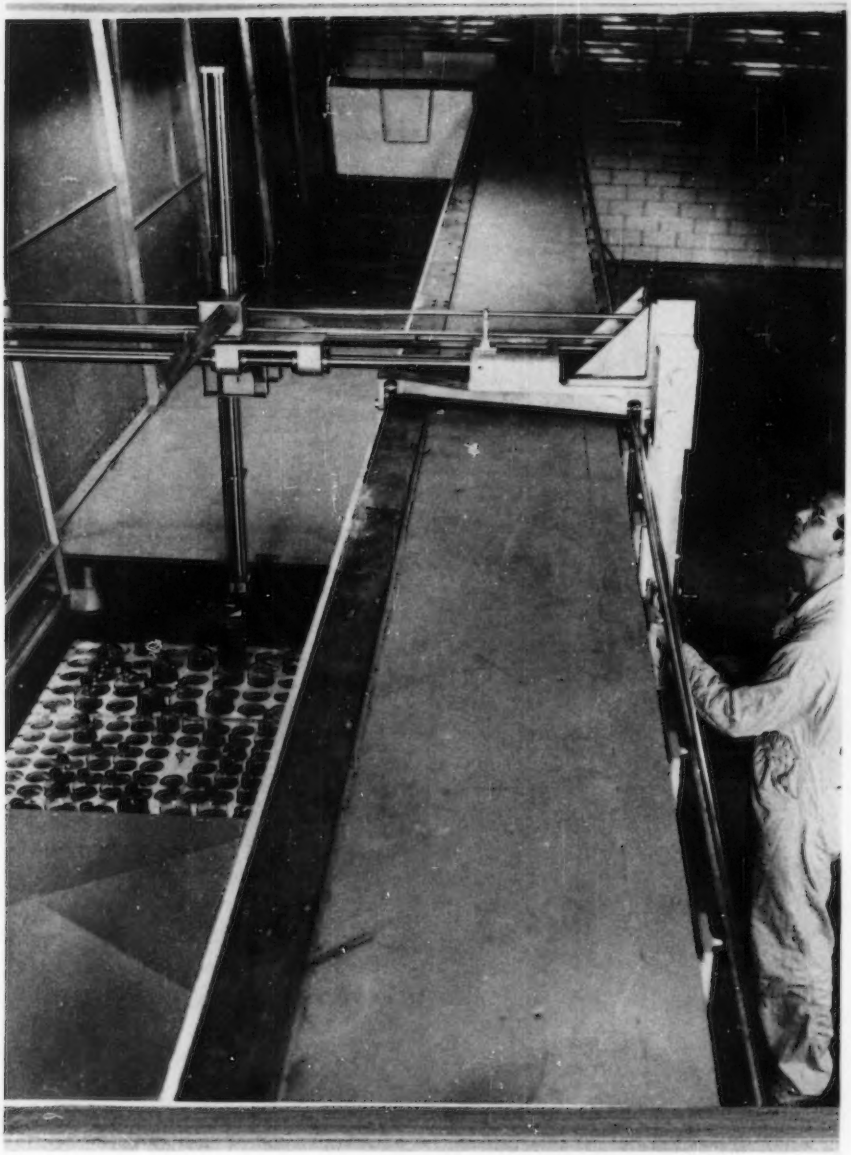

Fig. 1

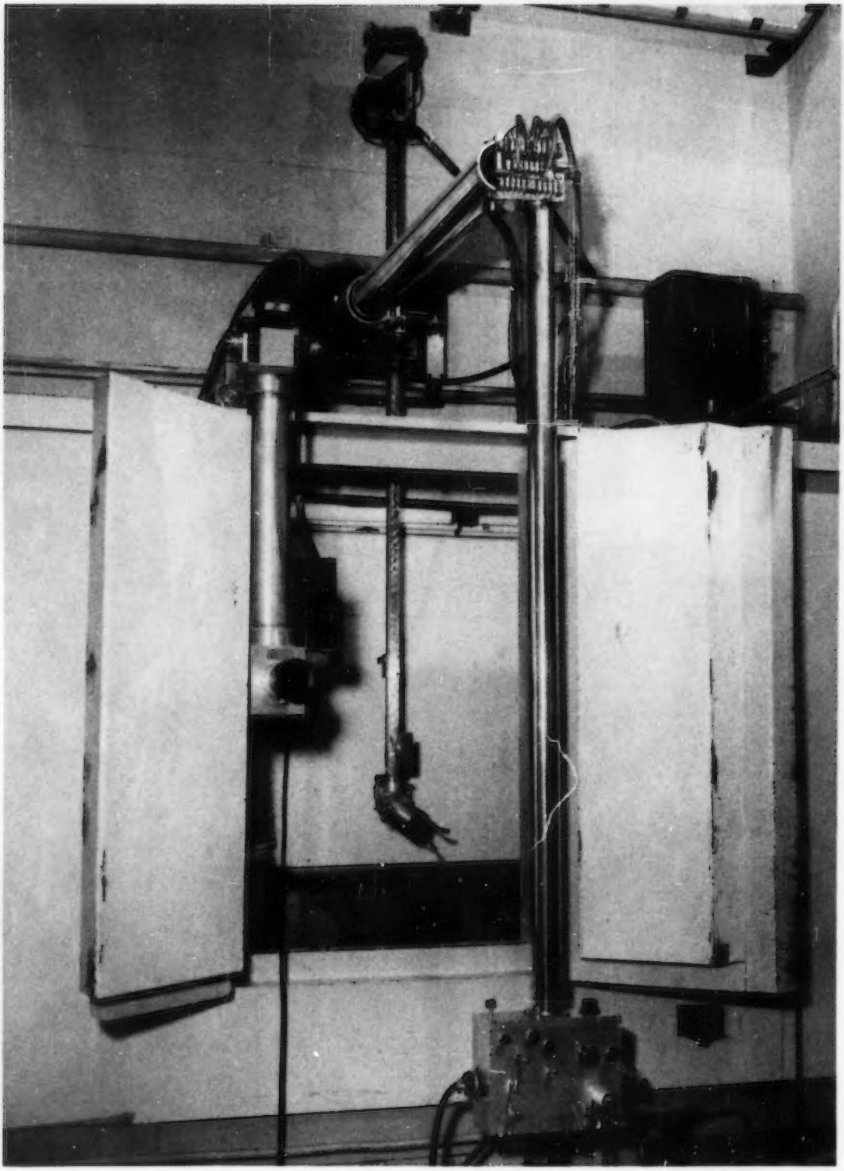

Fig. 2

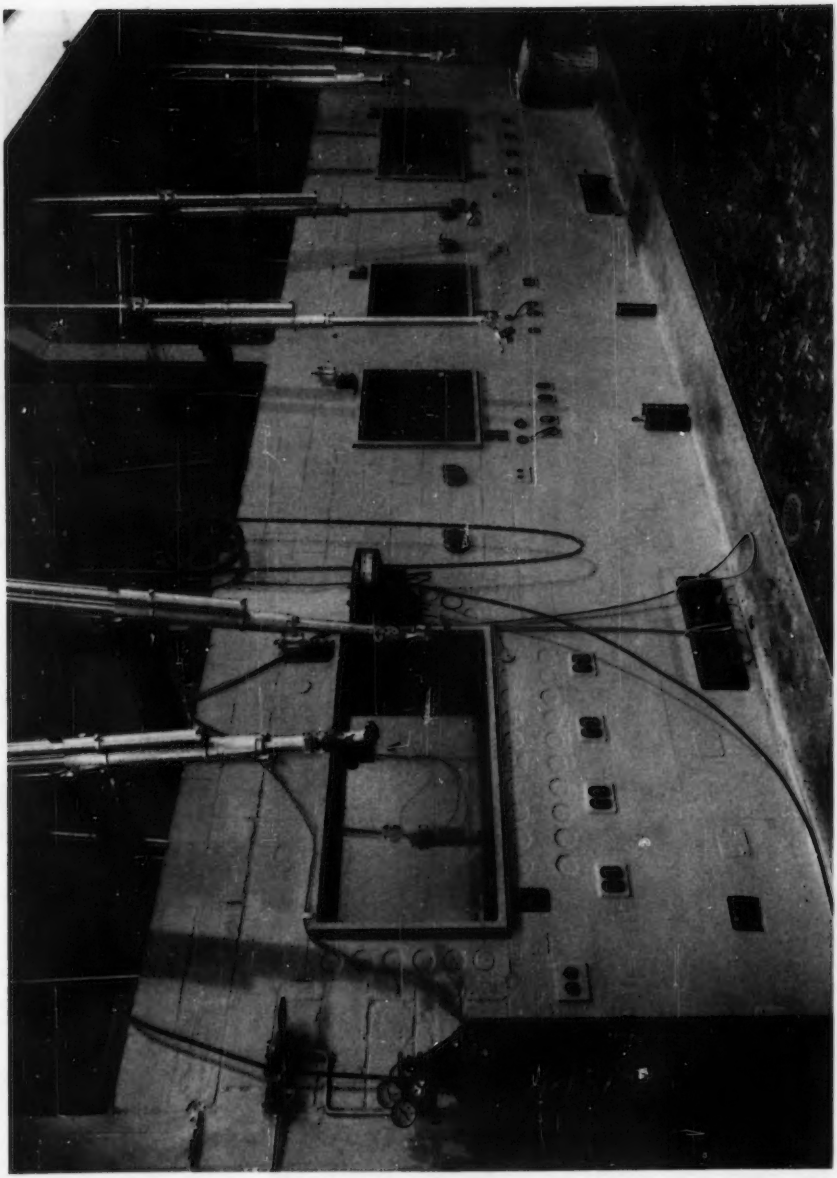

Fig. 3

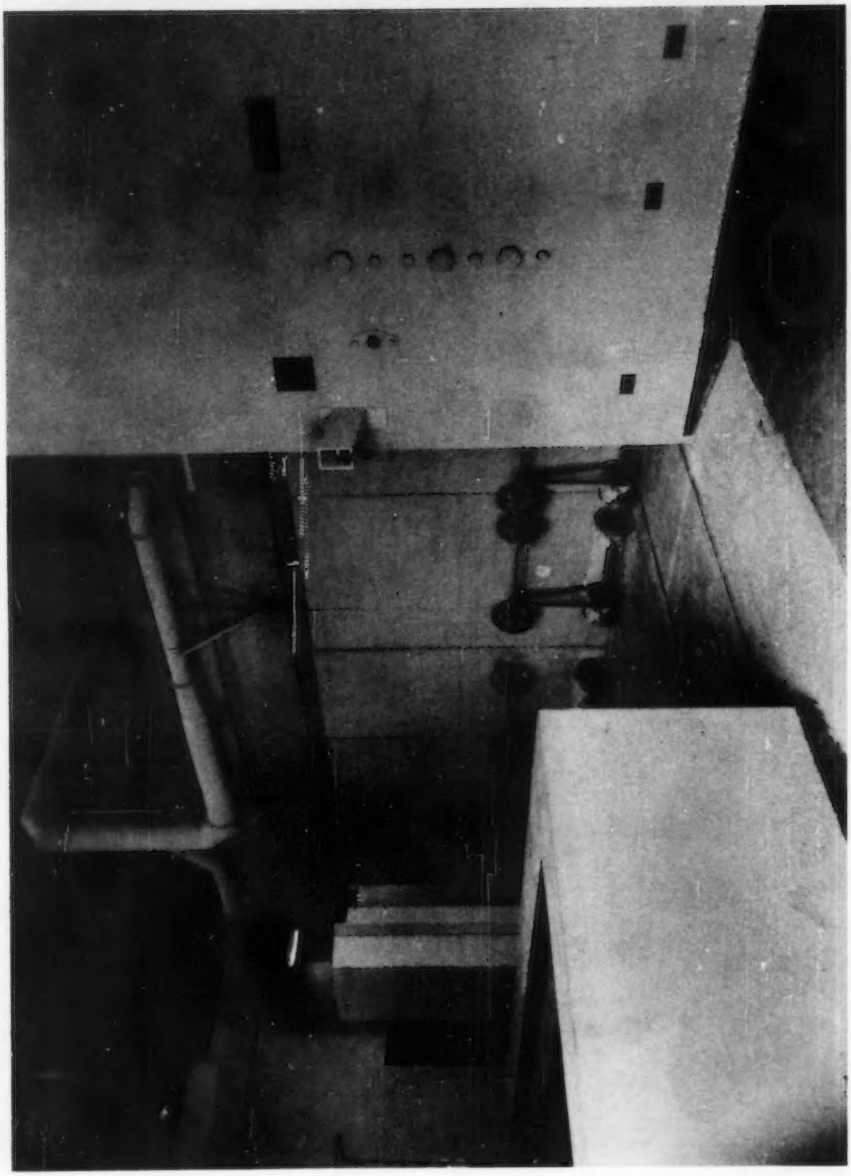

Fig. 4

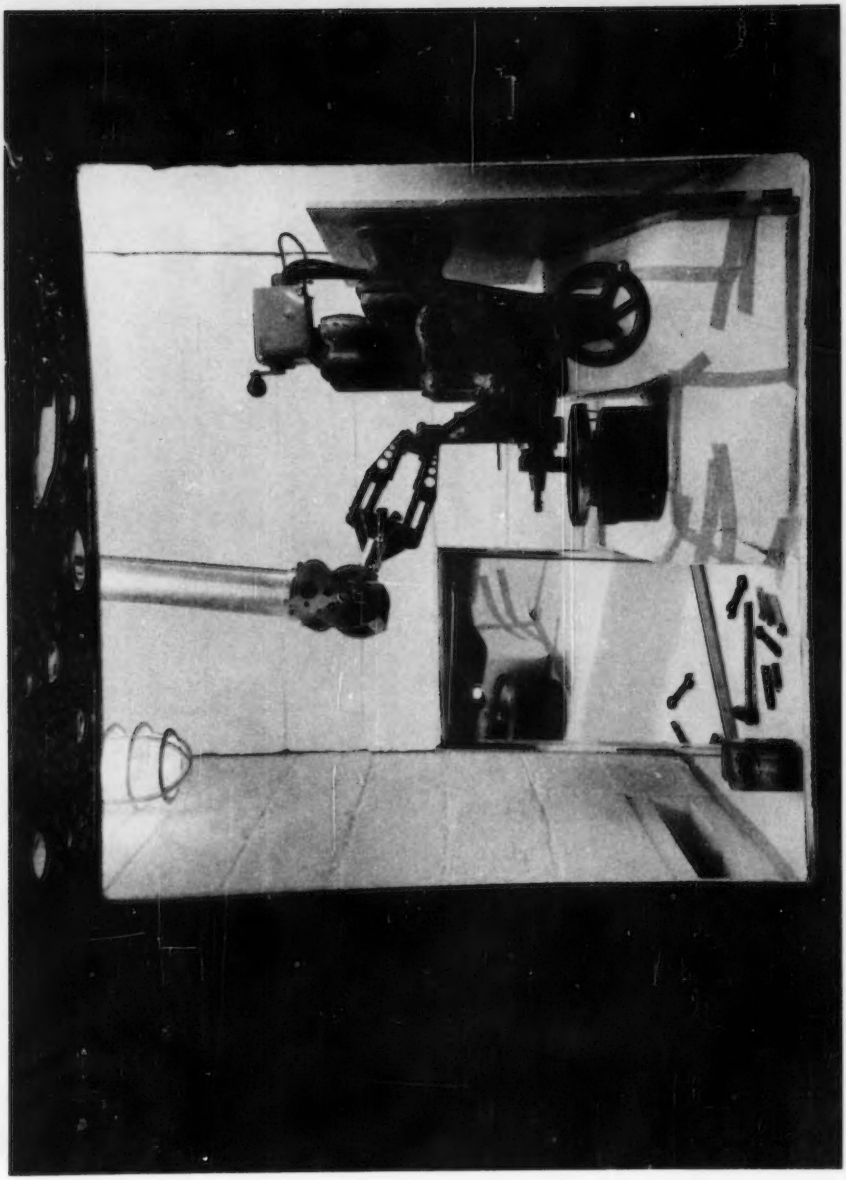

Fig. 5

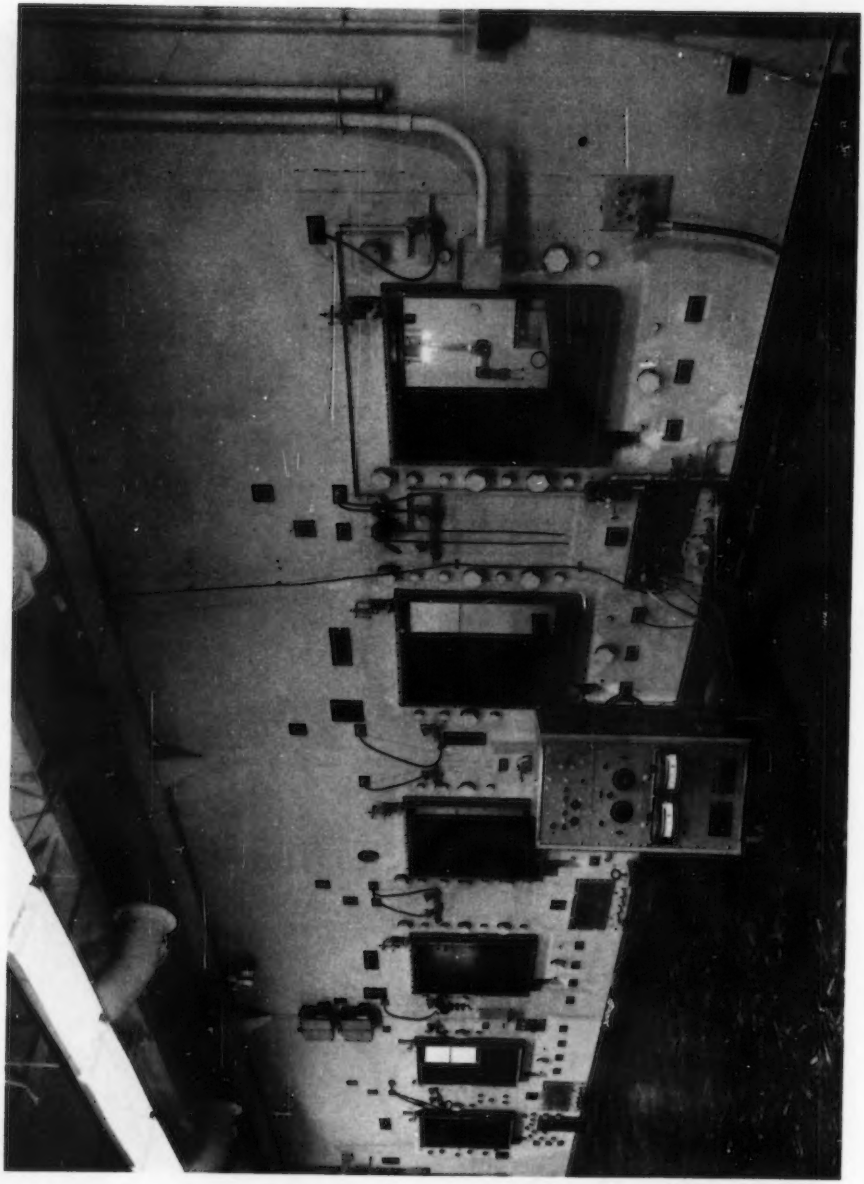

Fig. 6

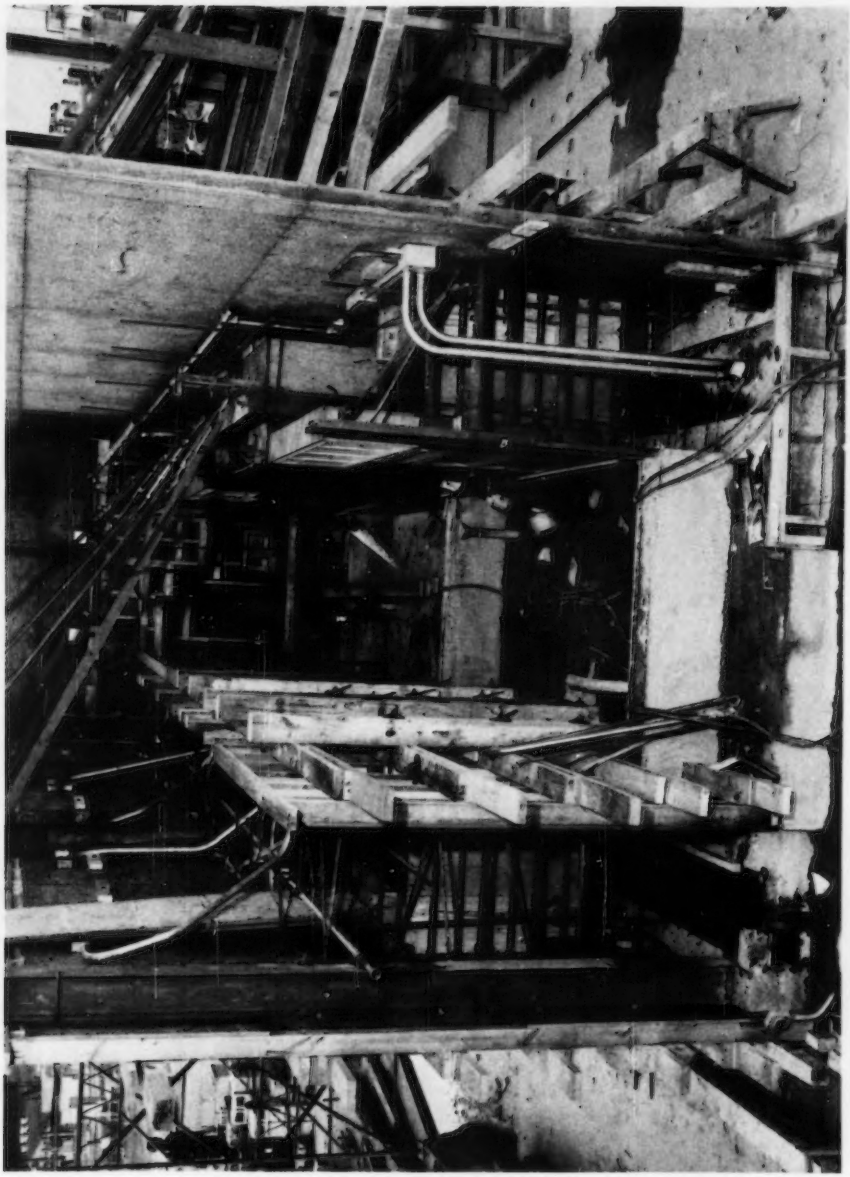

Fig. 7

447-11

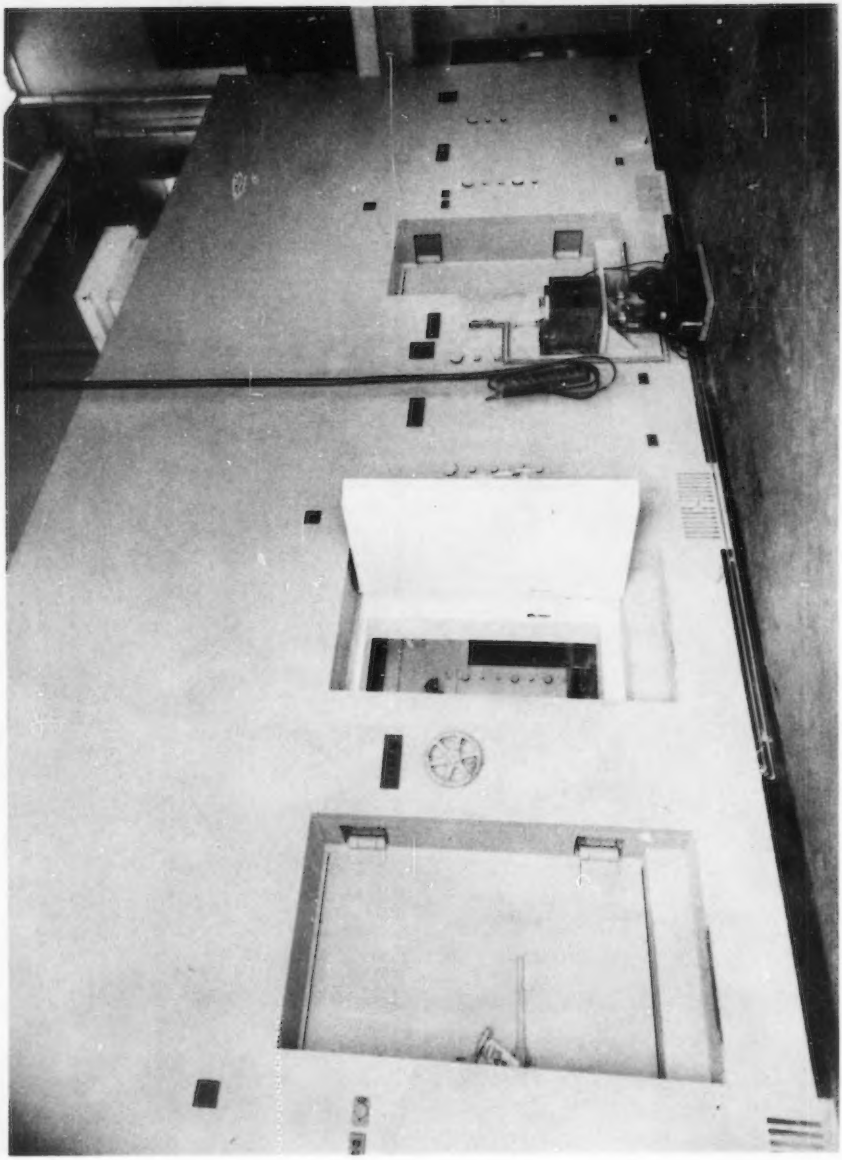

Fig. 8

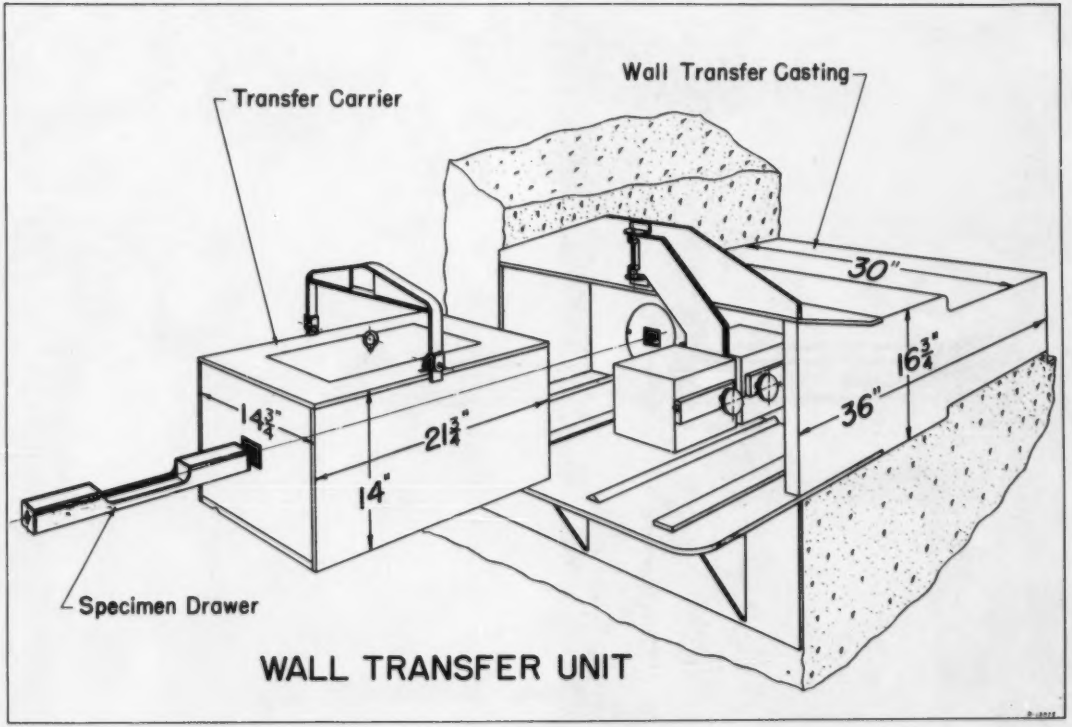
Transfer Carrier
Wall Transfer Casting
30"
16 3/4"
36"
14 3/4"
21 3/4"
14"
Specimen Drawer
WALL TRANSFER UNIT

Fig. 9

447-13

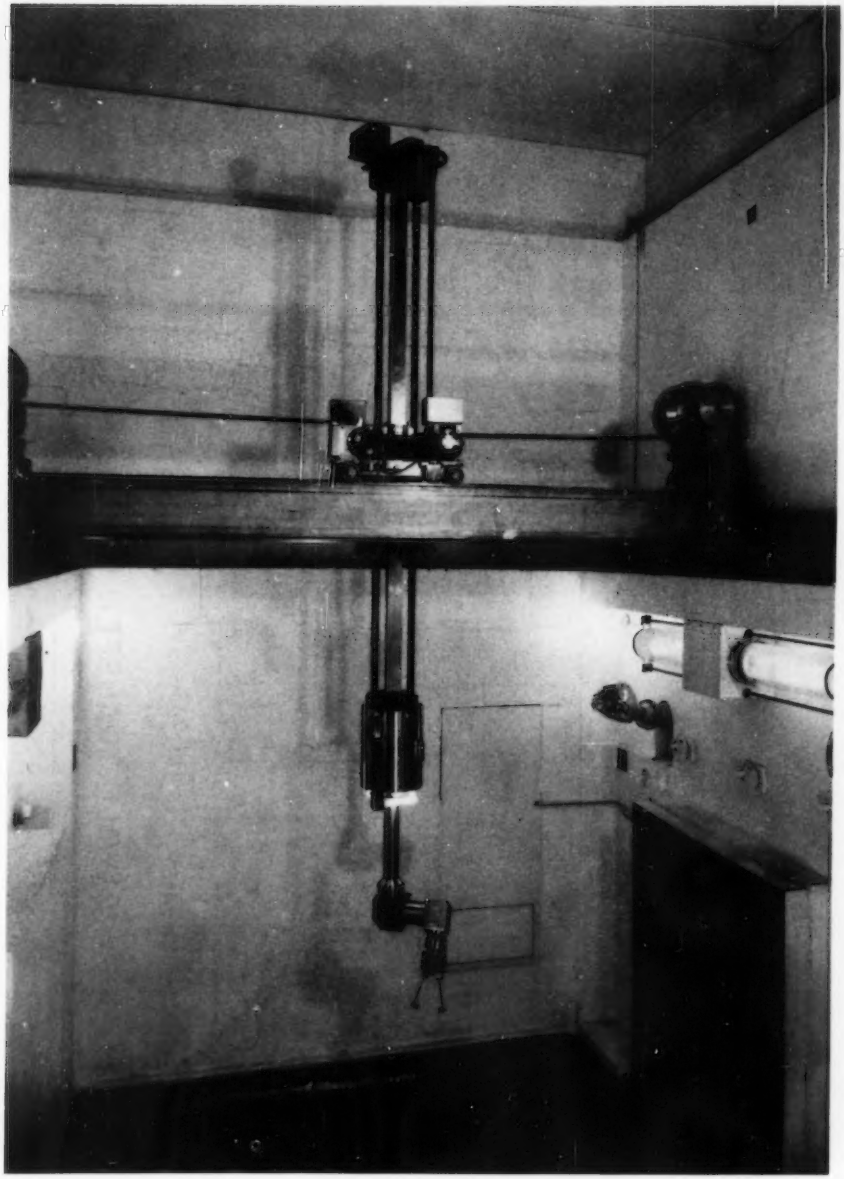

Fig. 10

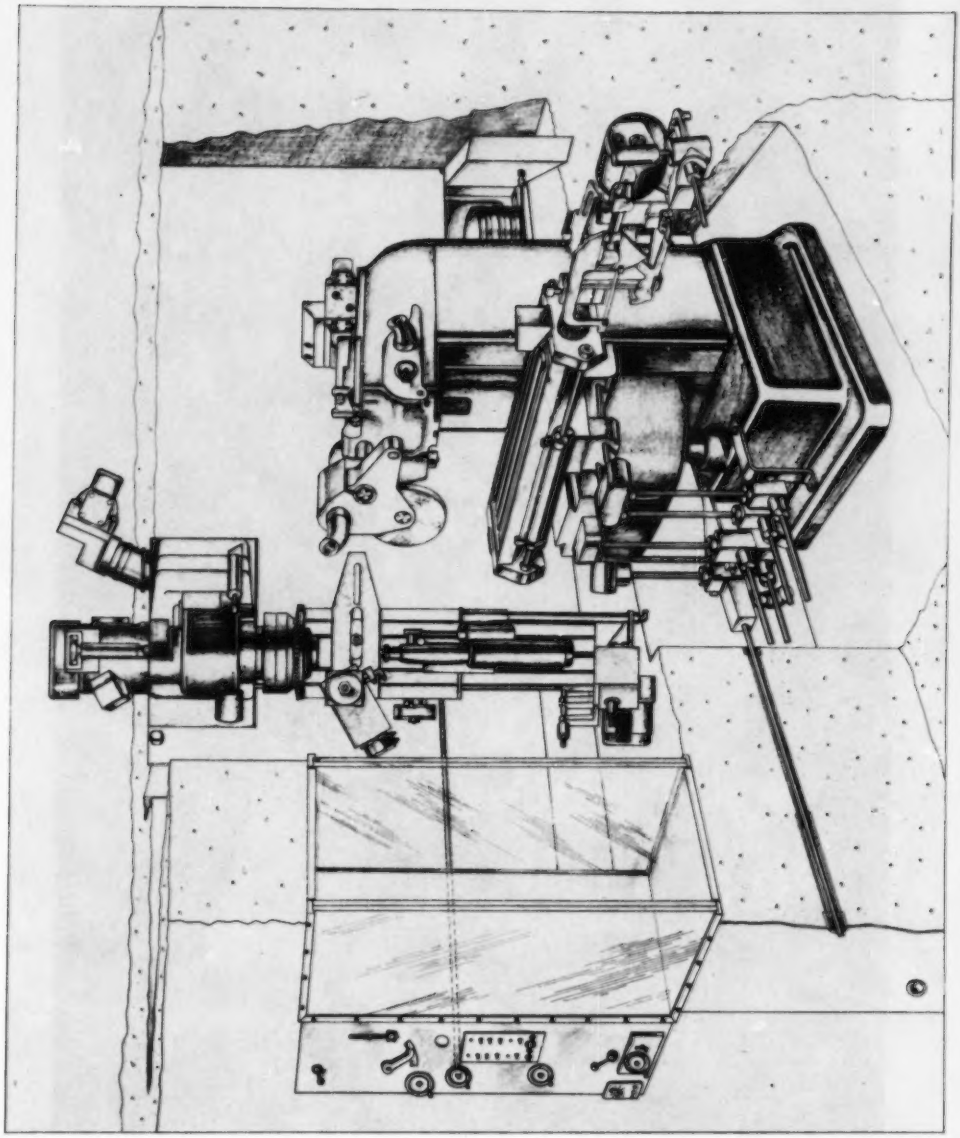

Fig. 11

447-15

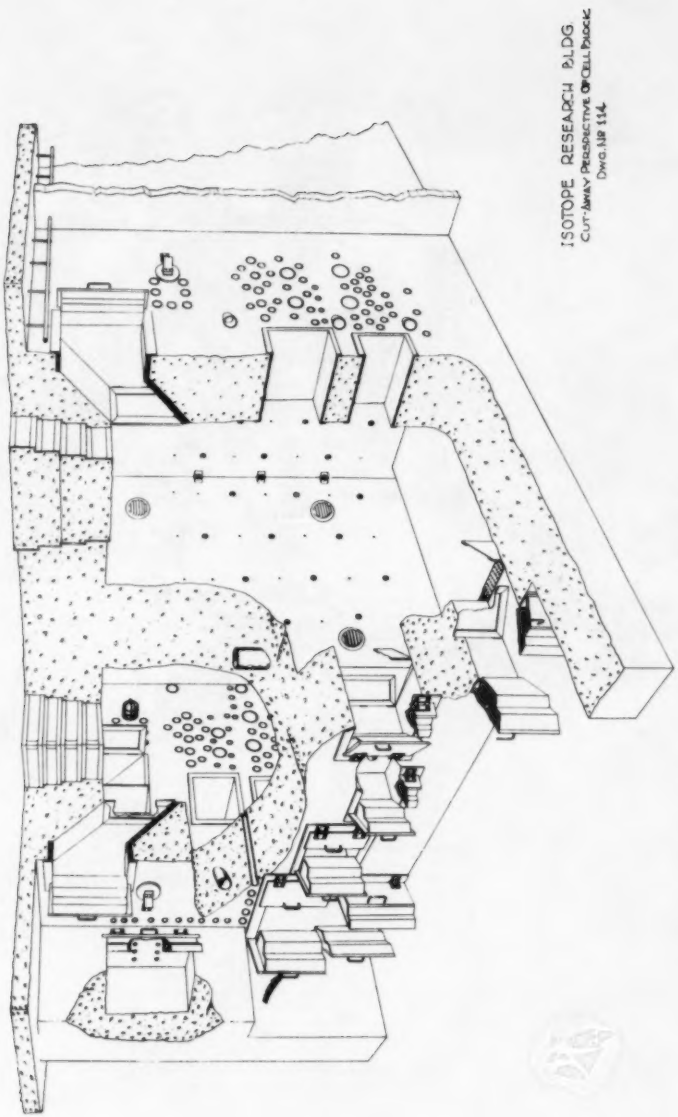
ISOTOPE RESEARCH BLDG.
CUT-AWAY PERSPECTIVE OF CELL BLOCK
DWG. NO. 114

Fig. 12

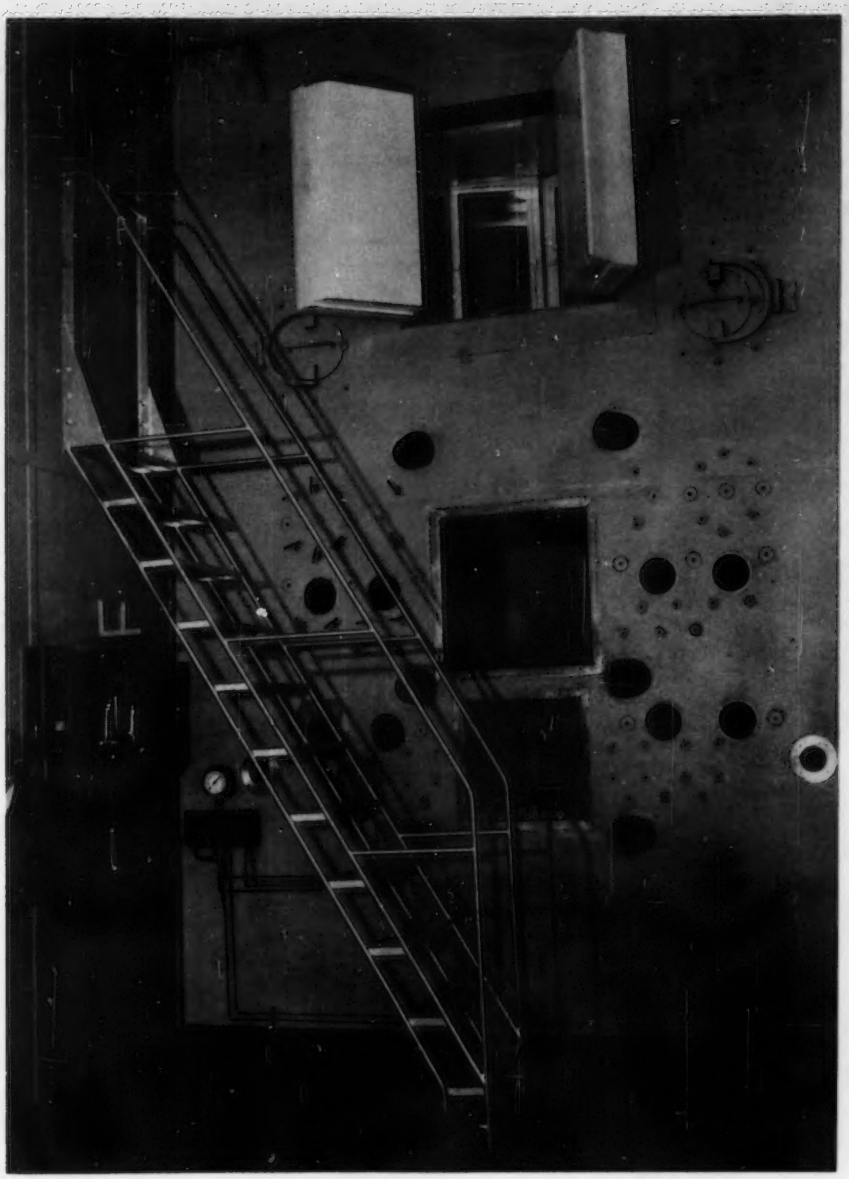

Fig. 13

447-17

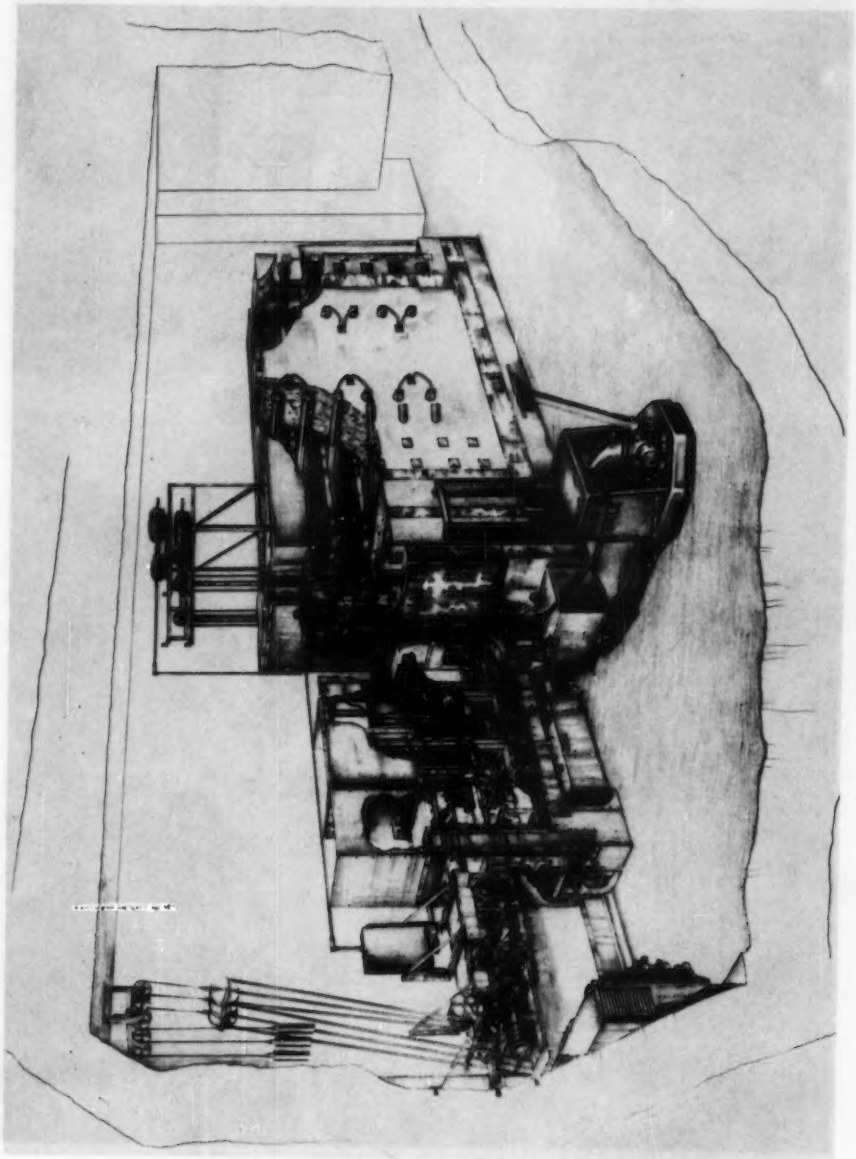

Fig. 14